MAP REPORT 82 2

GEOLOGY OF UPPER PARTS BECAGUIMEC, KESWICK AND NASHWAAK RIVERS CLOVERDALE-MILLVILLE MAP AREAS I-19, J-19, J-20, (Parts of 21 J/3, 21 J/6)

by
D V VENUGOPAL

A CANADA/NEW BRUNSWICK MINERALS AND FUELS SUB-AGREEMENT PROJECT
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MINERAL RESOURCES
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MAP REPORT 82-2

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MAP-AREAS I-19, J-19, J-20

(Parts of 21 J/3, 21 J/6)

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GEOLOGICAL SURVEYS BRANCH

DEPARTMENT OF NATURAL RESOURCES

1982

ABSTRACT

The report-area, situated 60 km northwest of Fredericton, is underlain by rocks of three distinct geological settings: the Miramichi Anticlinorium, the Fredericton Synclinorium, and the Chaleur Bay Synclinorium.

The older rocks of the Miramichi Anticlinorium comprise Cambro-Ordovician quartzite and slate. The younger part is an Ordovician succession of volcanic rocks interbedded with slate and chert, and overlain by greywacke.

The Fredericton Synclinorium, lying to the southeast of the Miramichi Anticlinorium, contains a thick sequence of Silurian greywacke and slate referred to as the Kingsclear Group.

Rocks included in the Chaleur Bay Synclinorium form a southeast-trending graben within the Miramichi Anticlinorium. The graben is underlain by Silurian calcareous slate, limestone, maroon slate and graptolitic sandstone of the Smyrna Mills Formation and by the Devonian Tobique Group. Volcanic rocks interbedded with quartzose sandstone and slate, and overlain by conglomerate and lithic sandstone form the Tobique Group.

Flat-lying red and grey sandstone and conglomerate of Carboniferous age sit unconformably on the folded rocks of the Chaleur Bay Synclinorium.

Several Devonian plutons occur within the report-area. Gabbro, containing small stocks of hornblende-bearing granite, intrudes rocks of the Smyrna Mills Formation and Tobique Group. Foliated tonalite and granodiorite, containing xenoliths of sillimanite-bearing schist, intrude Cambro-Ordovician country rocks and produce a narrow cordierite-andalusite contact aureole. A Jurassic diabase dyke intrudes the foliated tonalite. Plutons of mainly biotite granite are localized along the faulted boundaries of the Miramichi Anticlinorium with the Chaleur Bay Synclinorium and Fredericton Synclinorium. Cordierite, andalusite, and garnet occur in Silurian rocks of the Kingsclear Group up to 1 km from the granite contact.

Chalcopyrite and galena mineralization occurs in Ordovician tuffs north of Millville. Galena and sphalerite veins are located in Devonian felsic volcanic rocks near Taffy Lake. Chalcopyrite associated with pyrite is found in Devonian gabbro northwest of Becaguimec Lake.

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GEOLOGY OF THE UPPER PARTS BECAGUIMEC, KESWICK AND NASHWAAK RIVERS - CLOVERDALE - MILLVILLE

INTRODUCTION

This report and the accompanying maps were produced as part of a five year joint mapping project carried out by the Geological Surveys Branch of the New Brunswick Department of Natural Resources and the Federal Department of Regional Economic Expansion. The aim of the project is to provide detailed maps (4 inches = 1 mile scale) and reports on the geology of west-central New Brunswick. It is hoped that the ensuing information will encourage mineral exploration in the area.

The map region comprises quarter-mile map-areas I-19, J-19, and J-20 (Plates 80-73A, 80-74A, 80-75A), an area of approximately 500 km^2 (Figure 1).

Map-area J-20 is bounded by meridians of latitude 46°06' and 46°12'N and parallels of longitude 67°00' and 67°12'W; map-areas I-19 and I-20 are bounded by meridians of latitude 46°12' and 46°18' and parallels of longitude 67°00' and 67°24'W.

The area, situated approximately 60 km northwest of Fredericton, is accessible via the Trans-Canada Highway and several subsidiary roads. The community of Cloverdale is located in the northwest corner of the region and Hainesville in the southwest corner.

Bedrock exposure is generally good along rivers, streams, and a few road cuts but poor on the rounded hills and in low lying areas underlain by granitoid rocks.

Mapping was carried out during the summer of 1979 with the able assistance of Wayne Stewart, Kevin Menzies and Joe McCutcheon. Field trips and discussions with project manager L. R. Fyffe have contributed considerably to the preparation of the report. J. Chandra carried out geophysical traverses over a mineralized showing. L. R. Fyffe, D. E. Gemmell, J. B. Hamilton and B. M. W. Carroll are gratefully acknowledged for critically reading the manuscript. Diane Blair typed the manuscript and Ronald Phillips drafted the figures and maps.

Early regional geological descriptions of the area are given by Bailey (1884, 1901), Ells (1907), Gesner (1842), Hind (1865) and Robb (1869). More recently, the Geological Survey of Canada (Anderson and Poole 1959) published a preliminary geological map of York, Carleton, Sunbury and Northumberland counties on a scale of 1:126,720 (1 inch = 2 miles). Subsequently Anderson (1968) published a memoir on the geology of Woodstock,

Millville and Coldstream area. A brief geological description of the area is given by Hamilton (1965).

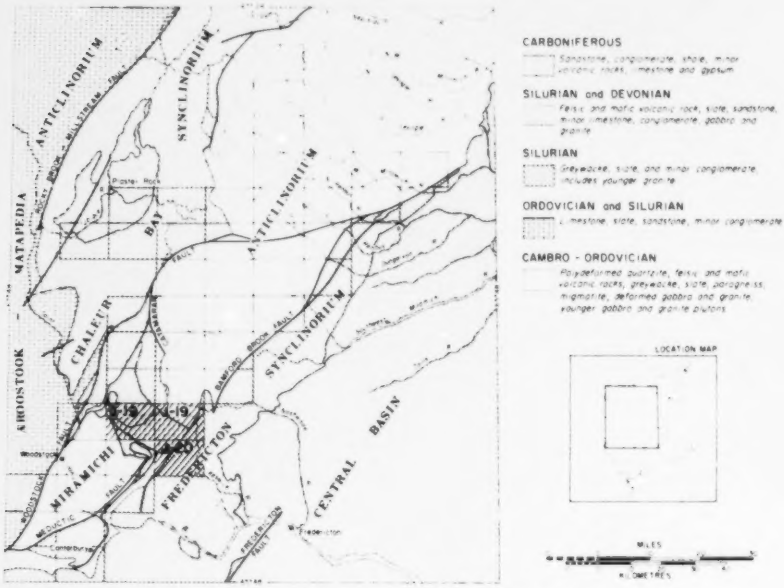

Figure 1. Index map showing locations of I-19, J-19 and J-20 map-areas (shaded).

Martin (1970) grouped the Devonian granitic intrusions in southern New Brunswick into subsolvus and hypersolvus granite based on chemical and petrological studies. McGrath (1970) subdivided the Pokiok Granite based on magnetic susceptibility studies.

PHYSIOGRAPHY

The south-central portion of the report-area is marked by a west-northwestern chain of peaks underlain by volcanic rocks (Figure 2). Several lakes are localized along the southwestern margin of these hills. The eastern part of the area, underlain by Hawkshaw Granite, is low-lying, swampy and drift covered. In the southeast, Mularchy Peak and Crabbe Mountain occur within the metamorphic aureole of the Hawkshaw Granite. Narrows Mountain, to the north, lies within the aureole

of the Nashwaak Granite. The western part of the area, near Cloverdale, forms a plateau underlain by Carboniferous rocks.

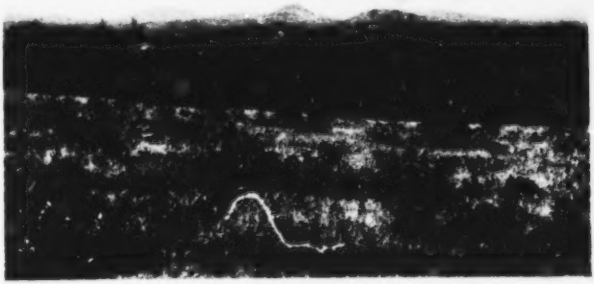

Figure 2. West-northwestern chain of hills underlain by Devonian volcanic rocks (looking northwest from Howland Ridge).

REGIONAL GEOLOGICAL SETTING

The regional geology of west-central New Brunswick is summarized in Figure 1. The report-area lies within three tectonostratigraphic zones: the Miramichi Anticlinorium, the Chaleur Bay Synclinorium and the Fredericton Synclinorium. The general geology of the area is shown in Figure 3 and Table 1 summarizes the stratigraphy.

In the report-area, the rocks of the Miramichi Anticlinorium are divided into three units. The oldest unit comprising Cambro - Ordovician quartzite and slate is overlain by a sequence of mafic and felsic volcanic rocks referred to as the Pocomoonshine Volcanics (Venugopal 1978). The volcanic sequence is overlain by a sequence of greywacke, slate, and conglomerate of Ordovician age. The rocks of the Miramichi Anticlinorium have undergone deformation during the Taconian and Acadian orogenies and display greenschist to upper amphibolite grade regional metamorphism.

The rocks of the Fredericton Synclinorium comprise a Silurian sequence of black slate and greywacke referred to as the Kingsclear Group (Kingsclear Series, Freeze 1936). The rocks were deformed during the Acadian orogeny and are locally metamorphosed to cordierite grade in the contact aureoles of

JURASSIC

Jm — *Diabase dyke*

PENNSYLVANIAN

Mountain View Formation

Ps — *Grey sandstone and conglomerate*

MISSISSIPPIAN

Carlisle Formation

Mli — *Red conglomerate and sandstone, minor mudstone and nodular limestone*

Mmv — *Grey basalt*

DEVONIAN

Hawkshaw Granite

Df_{4a}, *grey to pink, megacrystic biotite granite*

Df_{4b}, *grey, equigranular biotite and hornblende-biotite granite*

Df_{4c}, *pink, equigranular muscovite-biotite granite*

Nashwaak Granite

Df_{3a}, *pink, equigranular to subporphyritic biotite granite*

Df_{3b}, *pink, equigranular biotite-muscovite-garnet granite*

Howard Peak Granodiorite

Df_2 — *Grey foliated hornblende-biotite tonalite and granodiorite containing xenoliths of schist and injected by granite veins*

Df_1 — *Greyish pink porphyritic hornblende-biotite and biotite granite*

Dm_2 — *Grey diabasic gabbro varying to pinkish grey monzodiorite*

Becaguimec Lake Gabbro

Dm_1 — *Grey and green ophitic gabbro, minor troctolite and gabbro pegmatite*

LOWER DEVONIAN

TOBIQUE GROUP

Ds_2 — *Grey conglomerate, lithic sandstone and slate*

Dfv — *Greyish green to pink felsic flows, tuff and breccia, minor quartz feldspar porphyry*

Dmv — *Greyish green mafic volcanic rocks*

Ds_1 — *Grey quartzose sandstone, siltstone and slate*

SILURIAN

Smyrna Mills Formation

Ss_2 — *Grey calcareous slate, maroon and dark grey slate, grey laminated sandstone, bluish grey limestone*

KINGSCLEAR GROUP

Ss_1 — *Grey to greenish grey greywacke and dark grey slate*

MIDDLE ORDOVICIAN

Belle Lake Slate

Os_2 — *Grey greywacke and slate*

Pocomoonshine Volcanics

Ofv — *Greyish green to pink felsic volcanic flows and tuff, minor maroon volcanic breccia*

Omv — *Green and purple mafic volcanic rocks*

Os_1 — *Grey chert, argillite and slate, red and green manganiferous slate*

CAMBRIAN-ORDOVICIAN

COs — *Green quartzite and slate*

Geology by D.V. Venugopal, 1979 (revised 1982)

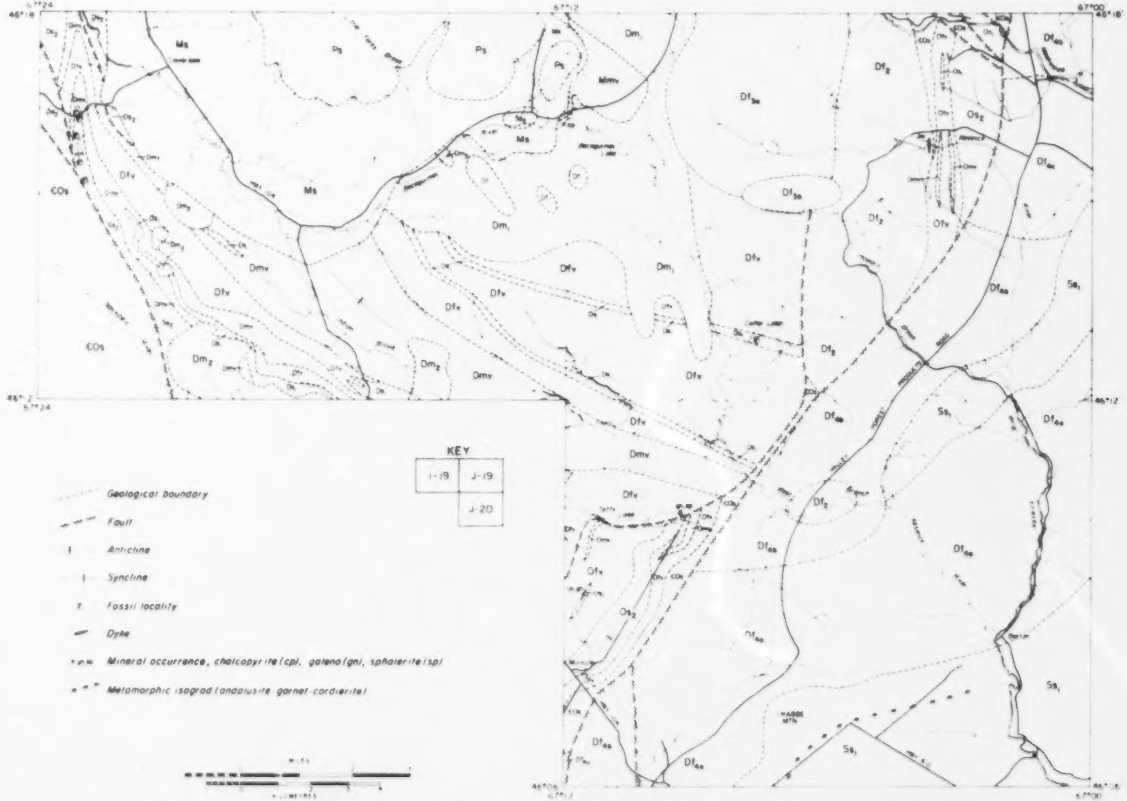

Figure 3. Generalized geology of upper parts Becaquimec, Keswick and Nashwaak River-Cloverdale-Millville Areas

TABLE 1

Table of Formations

Era	System	Formation	Map Unit	Lithology
Phanerozoic	Jurassic		Jm	Diabase dike
	Pennsylvanian	Mountain View Formation	Pm	Grey sandstone and conglomerate
	Mississippian	Carlisle Formation	Ms	Red conglomerate and sandstone; minor mudstone and nodular limestone
			Mmv	Grey basalt
	Devonian	Hawkshaw Granite	Df_{4c}	Pink, equigranular muscovite-biotite granite
			Df_{4t}	Grey, equigranular biotite and hornblende biotite granite
			Df_{4x}	Grey to pink, megacrystic biotite granite
		Nashwaak Granite	Df_{3k}	Pink, equigranular biotite-muscovite-garnet granite
			Df_{3a}	Pink, equigranular to subporphyritic biotite granite
		Howard Peak Granodiorite	Df_2	Grey foliated hornblende-biotite tonalite and granodiorite containing xenoliths of schist and injected by granite veins
			Df_1	Greyish pink porphyritic hornblende-biotite and biotite granite
			Dm_2	Grey diabasic gabbro varying to pink and grey monzodiorite
		Nerepis/Lake Gabbro	Dm_1	Grey and green ophitic gabbro; minor tremolite and gabbro pegmatite
	UNCONFORMITY			
	Lower Devonian	Tobique Group	Dq_3	Grey conglomerate, lithic sandstone and slate
			Dfv	Greyish green to pink felsic flows, tuff and breccia; minor quartz-feldspar porphyry
			Dmv	Greyish green mafic volcanic rocks
			Dq_2	Grey quartzose sandstone, siltstone and slate
	Silurian	Smyrna Mills Formation	Sq_2	Grey, calcareous slate, narrow and dark grey slate; grey laminated sandstone, siltstone, grey limestone
		Kingsclear Group	Sej	Grey to greenish grey greywacke and dark green slate
	Middle Ordovician	Belle Lake Slate	Oq_2	Grey greywacke and slate
		Undifferentiated Volcanics	Ofv	Greyish green to pink felsic volcanic flows and tuff; minor maroon volcanic breccia
			Omv	Green and purple mafic volcanic rocks
			Osj	Grey chert, argillite and slate, red and green manganiferous slate
	Cambrian-Ordovician		ϵ-o	Green quartzite and slate

the late Acadian plutons. The Hawkshaw Granite separates the Fredericton Synclinorium from the Miramichi Anticlinorium to the north.

Rocks of the Chaleur Bay Synclinorium form a southeast trending graben within the Miramichi Anticlinorium. The Chaleur Bay Synclinorium is comprised of a Silurian sequence of interbedded calcareous slate, limestone, maroon slate and graptolitic sandstone conformably overlain by a succession of Devonian clastic sedimentary rocks and interbedded volcanics. The rocks of the Chaleur Bay Synclinorium are metamorphosed to lower greenschist grade and have been deformed during the Acadian orogeny.

In the northwestern section of the report-area relatively flat-lying red and grey sedimentary rocks of Carboniferous age rest unconformably on rocks of the Chaleur Bay Synclinorium.

STRATIGRAPHY

CAMBRIAN-ORDOVICIAN

Quartzite-Slate Sequence (Unit €Os): This unit occurs along the northwestern margin of the Hawkshaw Granite in map-area J-20, on the Nashwaak River in northern J-19, and along the western border of map-area I-19.

The quartzite is light greyish green to olive green and displays white to buff weathering. Bedding, ranging in thickness from a few centimetres to approximately one metre, is generally massive but locally is graded. The quartzite beds are typically cut by a number of quartz veins. Light green slate is interbedded with the quartzite.

The quartzite unit along the northwestern contact of the Hawkshaw Granite shows no evidence of contact metamorphism within the report-area suggesting its contact with the granite is faulted. This is further supported by the highly contorted and phyllitic nature of the rocks along the West Keswick River in map-area J-20 (Figure 4).

Thick-bedded quartzite on the Nashwaak River in map-area J-20 is faulted against the Hawkshaw Granite in the east and against Ordovician volcanic rocks in the west. Exposures on the river at the Narrows are folded into recumbent folds related to regional Taconian deformation (Figure 5). Quartzite and slate on the western border of map-area I-19 are separated from Silurian rocks by a northwesterly trending fault that is intruded by diabase south of Pole Hill.

The quartzite-slate sequence is lithologically similar to rocks which form the base of the Tetagouche Group in northern New Brunswick (Helmstaedt 1971) and to those in western New Brunswick near the Maine border (Lutes 1979) which have been

correlated with the Grand Pitch Formation of Maine (Neuman 1967). The Grand Pitch Formation underlies rocks of Arenigian to Llandeillian age (Neuman 1968) and is therefore no younger than Early Ordovician.

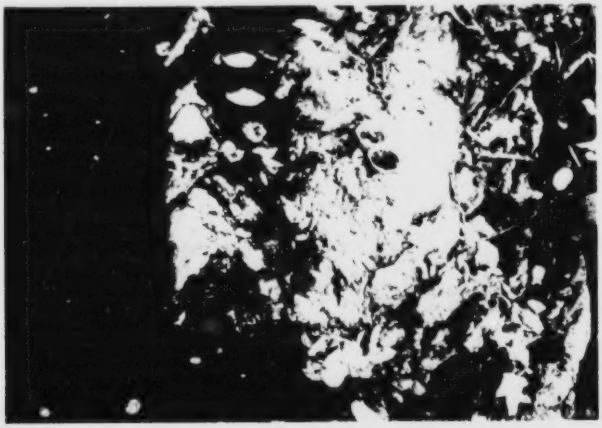

Figure 4. Shallow-plunging folds in phyllite on West Keswick River.

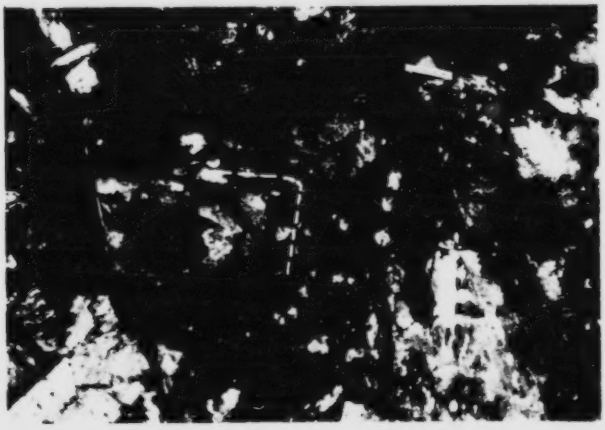

Figure 5. Recumbent folds at the Narrows on the Nashwaak River (nose of fold is in upper right).

ORDOVICIAN

Pocomoonshine Volcanics: A sequence of interbedded volcanic and sedimentary rocks referred to as the Pocomoonshine Volcanics (Venugopal 1978) occurs between Taffy Lake and Millville in map-area J-20 and as a belt extending from south of Howard Peak Lake to the northern border of map-area J-19.

Felsic Volcanic Rocks (Unit Ofv) are the predominant rock type within the Pocomoonshine Volcanics in the report-area. The felsic volcanic rocks form a wide belt exposed along the Nackawic River approximately 2 km north of Millville in map-area J-20. They are also exposed in a northeasterly trending belt east of Millville and as a northerly trending belt extending from the eastern flank of Howard Peak to the Nashwaak River northwest of Narrows Mountain in map-area J-19.

The felsic volcanic rocks comprise tuff, flows, and breccia in decreasing order of abundance. The tuff is typically greyish green, fine-to medium-grained, with greyish brown to buff weathered surfaces. The tuff is composed primarily of rock fragments with lesser quartz and feldspar phenocrysts in a microcrystalline matrix. The rock fragments, varying from a few millimetres to approximately one centimetre in length comprise felsic and mafic volcanic fragments with minor siltstone and slate fragments. The matrix which forms approximately 25-30% of the rock is a fine-grained matte of chlorite, quartz, sericite, and opaques. The fragments are intensely sheared and numerous calcite-filled fractures transect the rock. Approximately 2 km due north of Millville two diamond-drill holes by Rio Tinto Canadian Exploration Limited (N.B.D.N.R. Assessment file # 472612, 1980) intersected tuff beds interbedded with graphitic argillite.

Pink to greyish green and light pink to buff weathering felsic volcanic rocks exposed on the Nackawic River approximately 2 km north of Millville exhibit flow structures. The thickness of the flows is in the order of a few centimetres to approximately one metre. Minor volcanic breccia float was also observed in the above location and the Rio Tinto drill holes intersected breccia in a zone approximately 10 m thick. The breccia is mottled red and green and contains 1 to 2 centimetre long angular fragments cemented by a recrystallized chlorite-sericite matrix. The fragments are predominantly felsic volcanic rocks with lesser milky white quartz and chloritized fragments. The red color is probably due to hematitic alteration. Similar breccia was observed on the Keswick River northeast of Howard Peak.

Sedimentary Rocks (Unit Osl) are interbedded with the felsic volcanic rocks. An exposure of red and green manganiferous slate is located in a field approximately 1.3 km northeast of Millville. Approximately 300 m southwest of this exposure an isolated outcrop of iron formation was observed. In a quarry, approximately 1 km south of Taffy Lake, thin lenticular beds of dark grey chert are interbedded with red manganiferous slate. Grey argillite is interbedded with felsic volcanics on the western flank of Narrows Mountain. Grey slate on the

Nashwaak River, although not associated with volcanic rocks, is included in this unit.

Mafic Volcanic Rocks (Unit Omv), exposed approximately 1 km southeast of Smyth Pond in map-area J-20 and near Howard Peak Lake in map-area J-19, are typically greyish green to purplish green and weather light greenish buff. The volcanics are lithic tuffs and agglomerates containing mafic rock fragments ranging from a few millimetres to approximately 0.5 m in diameter.

The Pocomoonshine Volcanics are considered to conformably overlie the Cambro-Ordovician quartzite-slate sequence. Contacts between the units have not been observed in the report-area but outcrops within a few metres of the contact occurring in a field approximately 2 km east-northeast of Millville and along Keswick River approximately 1.3 km north of Howard Peak Lake show no evidence of faulting. Southwest of the report-area near Meductic (Venugopal 1979) and in the central part of New Brunswick (Irrinki 1980, Crouse 1981) the conformable relationship between the units has been established. The volcanics have been assigned an age ranging from Early to Middle Ordovician based on their similarity to rocks of the Tetagouche Group (Fyffe 1976) in the Bathurst area.

Belle Lake Slate (Unit Os_2): The Belle Lake Slate (Venugopal 1978) is exposed in a northeasterly trending belt along Howland Ridge in map-area J-20 and in a southerly trending wedge east of Narrows Mountain in map-area J-19. The unit is well exposed along the Nackawic River approximately 500 m north of Millville, along the Keswick River approximately 2 km northeast of Howard Peak Lake, and along the southern flanks of Narrows Mountain.

The Belle Lake Slate comprises an alternating sequence of slate and greywacke. In the Millville area, the greywacke is thin-bedded and tightly folded (Figure 6). In the Narrows Mountain area the greywacke is thick-bedded and graded (Figures 7, 8, 9). A typical greywacke from this area contains 35-50% matrix, 35-40% rock fragments, 7-12% quartz-clasts and 5-10% plagioclase and microcline clasts. The rock fragments are composed of slate, volcanic rocks and quartzite.

The nature of the contact between the Belle Lake Slate and the Pocomoonshine Volcanics is uncertain due to lack of continuity of rock exposure. The greywacke contains rock fragments derived from the volcanics and from the underlying quartzite sequence. The greywacke in the Millville area either overlies or is intercalated with the volcanic sequence but in the Narrows Mountain area, it clearly overlies the volcanics.

The slate-greywacke sequence of the report-area resembles the Belle Lake Slate of map-area G-22 (Venugopal 1978) and has been correlated with it in this report. Limestone, interbedded with similar greywacke in a quarry approximately 3 km northeast of South Waterville in map-area I-21 yielded early Middle Ordovician (late Llanvirnian) conodonts (Nowland 1979, Venugopal 1979).

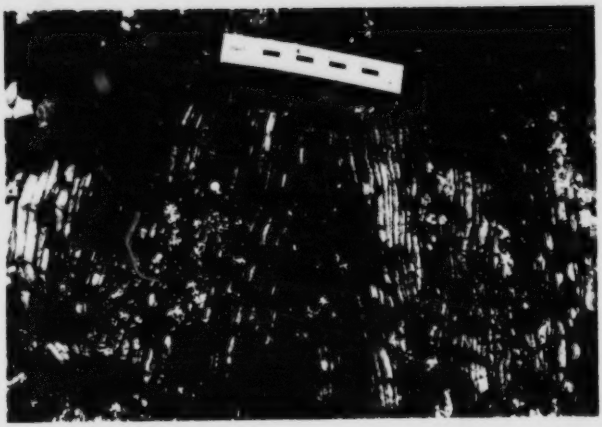

Figure 6. Thin-bedded greywacke on Nackawic River.

Figure 7. Slate fragments in thick-bedded greywacke on Narrows Mountain.

Figure 8. Grading in greywacke on Narrows Mountain.

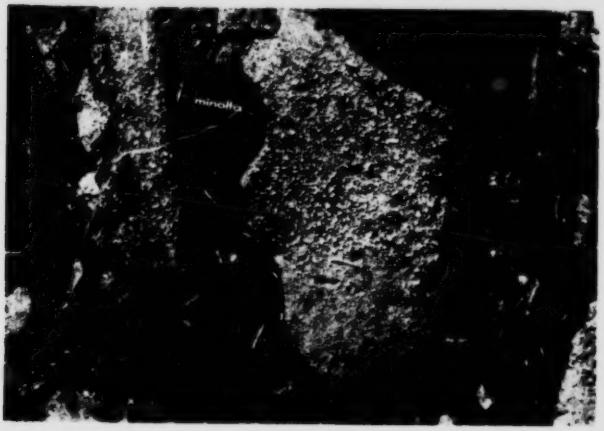

Figure 9. Gritty base to greywacke bed on Narrows Mountain.

SILURIAN

Silurian rocks occur in two tectonostratigraphic zones in the report-area. The Kingsclear Group is exposed east and southeast of Hawkshaw Granite and forms part of the Fredericton Synclinorium. The Smyrna Mills Formation to the northwest of the Hawkshaw Granite occupies part of the Chaleur Bay Synclinorium.

Kingsclear Group (Unit Ss_1): Kingsclear series was introduced by Freeze (1936) to describe a greywacke and slate sequence north of Fredericton. Except for a small area near Crabbe Mountain and a brook section 1 km northwest of Hayne in southeast map-area J-20 exposures of the unit are scarce.

In the Crabbe Mountain-Hayne area greywacke is medium grey to greenish grey and, near the granite contact, bluish grey. The greywacke displays a typical light grey weathered surface. Bedding varies from a few centimetres to approximately 1 m in thickness. Slate interbedded with the greywacke is dark grey and generally pyritiferous.

On a small brook approximately 1 km north of Hayne many of the greywacke and slate beds are calcareous. Locally the slate is spotted and in thin section the spots are observed to be euhedral porphyroblasts of calcite. A steep, northeasterly trending fault offsets greywacke beds near the mouth of the brook north of Hayne (Figure 10). An outcrop on the south side of the bridge at Hayne exhibits folds with a penetrative east trending axial plane cleavage that deforms an earlier cleavage. The outcrop is also transected by a narrow zone of breccia (Figure 11).

Figure 10. Thick-bedded greywacke displaced by steep fault (under hammer).

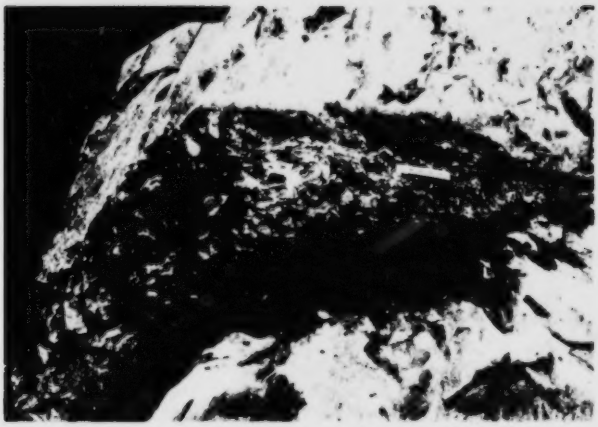

Figure 11. Fault breccia at Hayne.

The greywacke-slate sequence extends into the Burtts Corner area (Poole 1957) to the northeast. There, fossil localities on the Tay River and South Tay River indicate a Silurian age for the sequence.

Smyrna Mills Formation (Unit Ss_2): This unit is found in northwestern I-19 map-area where it is exposed on Highway 104 from Cloverdale and on a logging road running south from Pole Hill. A separate occurrence is found along the Becaguimec River in northeastern I-19 map-area.

On the Highway 104 at Pole Hill, the unit comprises tightly folded, grey calcareous slate containing interlaminations of the aphanitic limestone. These rocks resemble the lower part of the Silurian sequence immediately overlying the Carys Mills Formation to the west of the area (Anderson 1968).

East of Pole Hill, on the main road and on the logging road running south, the Silurian rocks are a sequence of maroon and dark grey slate; grey laminated, flaggy, graptolitic sandstone and thick-bedded bluish grey, brachiopod-bearing limestone. Graptolites are most plentiful in an outcrop on the north side of Highway 104 but are also found to the south near the faulted contact with Cambrian-Ordovician rocks. Brachiopods are abundant in an outcrop on the logging road where it crosses a tributary of Burlock Brook.

Fossil locality GSC 97092 at latitude 46°16'04"N and longitude 67°23'10"W about 650 m south of Pole Hill Road on

a southern tributary of Burlock Brook contains the following brachiopods: *Dalejina* sp., *Sphaerirhynchia* sp., *Isorthis* cf. *I. arcuaria*, *Merista* sp., *Lissatrypa* sp., *Leptaena "rhomboidalis"*, *Dicoelosia* sp., *Costistrophonella* sp., *Coelospira* sp. and *Megakozlowskiella* sp.

According to A. J. Boucot "This fauna is of Pridoli age as indicated by the presence of *Merista*, *Isorthis* of the *I. arcuaria* type, *Lissatrypa*, *Costistrophonella* and *Megakozlowskiella*, since *Megakozlowskiella* is unknown below the Pridoli and *Merista* plus this type of *Isorthis* are unknown in the Devonian. If GSC 97095 is stratigraphically close the case is even stronger because of the presence of *Resserella* in that collection, a strictly Silurian type shell. The overall aspect of the high diversity community suggests a *Dicoelosia-Skenidioides* Community type in the Benthic Assemblage 4-5 range, and biogeographically this is typical North Atlantic Region material. The *Dalejina* is too small for the Gedinnian and younger forms of the genus."

Fossil locality GSC 97093 at latitude 46°15'34"N and longitude 67°22'58"W about 1.65 km south of Pole Hill Road contains *Megakozlowskiella* sp. and *Atrypa "reticularis"*.

According to Boucot, "On its own merits this collection is merely in the Pridoli to about Schoharie age range (because of the presence of *Megakozlowskiella*), but if it comes close to the other two collections it should be Pridoli in age. Remarks made about the ecology and biogeography of the other two collections could then apply to this one."

Fossil locality GSC 97095 at latitude 46°16'25"N and longitude 67°23'08"W about 250 m west of Burlock Brook and just north of the Pole Hill Road contains: *Coelospira* sp., *Resserella* sp., *Lissatrypa* sp., *Euomphalopterus?* sp., *Atrypina* sp., *Gypidula* sp., *Atrypa "reticularis"*, *Howellella?* sp., *Leptaena "rhomboidalis"* and *Isorthis* cf. *I. arcuaria*.

Boucot states that: "That is a Wenlock-Pridoli, Silurian collection, but if close to GSC 97092 it could be easily assigned to the Pridoli. Ecologically and biogeographically it is also close to GSC 97092. It is of some interest that the Smyrna Mills collection has not previously yielded anything as young as the Pridoli, but the lithology in hand specimen is certainly consistent with that unit as I have seen it in Maine."

GSC locality 96219 at latitude 46°16'15"N and longitude 67°23'10"W on the north side of Pole Hill Road 200 m west of Burlock Brook contains the following graptolites: *Bohemograptus bohemicus* (Barrande), *Pristiograptus* cf. *tumescens* (Wood), *Pristiograptus dubius* (Suess), *Monoclimacis micropoma* (Jaekel), *Saetograptus* cf. *chimaera* (Barrande), *Saetograptus varians* (Wood), *Saetograptus colonus* (Barrande), *Saetograptus* cf. *incipiens* (Wood) and *Saetograptus* cf. *roemeri* (Barrande).

"The horizon indicated is *nilssoni* Zone, Ludlow, Silurian, probably upper *nilssoni* Zone" according to R. B. Rickards.

The late Silurian age confirms that the rocks east of

Pole Hill are equivalent to the upper part of the Smyrna Mills Formation.

A number of calcareous siltstone xenoliths of the Smyrna Mills Formation occur as roof pendants in the Ayers Lake gabbro southeast of Pole Hill. Brown iron carbonate and tiny incipient biotite flakes have grown over the cleavage in the siltstone.

An inlier of limestone surrounded by Carboniferous rocks crop out on a small knoll immediately north of South Becaguimec River in eastern map-area I-19. The limestone is generally greyish blue and massive, but on the road on the western flank of the knoll the rock displays greyish brown and greyish pink bands varying from a few millimetres to approximately 1 cm in thickness. The limestone is completely recrystallized to an extremely fine-grained (<0.01 mm) rock comprised of hydrogarnet, quartz, carbonate, chlorite, mica, epidote, opaques, and carbonaceous material. The hydrogarnet is an uncommon calcium-rich variety resulting from contact metamorphism of the carbonate rocks by the Becaguimec Lake Gabbro.

LOWER DEVONIAN

Tobique Group: An alternating succession of mafic and felsic volcanic rocks intercalated with sedimentary rocks is collectively included in the undivided Tobique Group. The name "Tobique Group" was formally introduced by St. Peter (1978) to include the basal Costigan Mountain Formation comprising predominantly felsic volcanic rocks and the overlying Wapske Formation comprising mainly mafic volcanic rocks intercalated with sedimentary rocks.

Mafic Volcanic Rocks (Unit Dmv) varying in thickness from a few metres to several hundreds of metres are interlayered with felsic volcanic and sedimentary rocks in the southwestern part of the report-area.

The mafic flows are typically dark greyish green and display light green to buff and light purple weathered surfaces. The rocks are generally amygdaloidal and massive to slightly porphyritic. A few exposures approximately 2 km north of Ayers Lake in map-area I-19 display flow-banding. Approximately 3.5 km north-northeast of Ayers Lake the flows in the vicinity of sedimentary rocks contain a number of fragments of siltstone and greyish blue chert.

The groundmass of the flows comprises 50-80% plagioclase, 15-30% chlorite, 5-10% leucoxene, 5-15% amygdules, 2-10% opaques and minor clinopyroxene. The amygdules contain variable amounts of quartz, chlorite, calcite, epidote, and prehnite. They vary from approximately 2 mm to 0.5 cm in diameter and are flattened parallel to the flow structure. The groundmass generally has a trachytic texture with plagioclase microlites having a subparallel orientation. In the immediate vicinity of cavities the groundmass is extremely fine-grained with a felty texture.

In the porphyritic rocks, euhedral to subhedral crystals of plagioclase ranging from 0.8 mm to 1.5 mm in length form 1 to 5% of the rock. The oligoclase and andesine microlites in the groundmass are rarely altered, whereas most of the mafic minerals intergrown with the microlites are altered to chlorite.

Approximately 1 km north of Smyth Pond in northwestern map-area J-20 a 10 m thick bed of hyaloclastite appears to overlie the only pillowed flow in the area. The hyaloclastite is a medium to dark green amygdaloidal rock comprising 5 to 10% plagioclase phenocrysts and 25-30% gas cavities in a devitrified and palagonitic glassy-matrix. The palagonitic matrix displays a crude flow structure outlined by a subparallel preferred orientation of glassy fragments, and flattened vesicles around plagioclase phenocrysts. A large number of vesicles contain yellowish brown palagonite, whereas a few others contain glass recrystallized to prehnite and pumpellyite.

Felsic Volcanic Rocks (Unit Dfv) are extensive in map-areas J-19 and I-19 where they are intercalated with the mafic volcanic and sedimentary rocks. The felsic volcanic rocks generally underlie prominent peaks whereas the mafic volcanic rocks generally occur along flanks of hills or in low-lying areas.

Felsic flows are greyish green to pink, equigranular to slightly porphyritic, and display light pink to buff weathered surfaces. The equigranular flows comprise a microcrystalline matte of quartz and feldspar with lesser variable amounts of epidote, chlorite, opaques and devitrified spherulites. The mafic minerals have a slightly preferred orientation parallel or subparallel to the flow structure. The porphyritic rocks, phenocrysts of embayed quartz and plagioclase form 5 to 10% of the rock.

In map-area J-19 1 km north-northeast of Trout Lake and near Pughs Peak felsic flows in the proximity of faults are cataclastically deformed and display intense fracturing and mortar texture. Randomly oriented biotite, tremolite, hornblende, and prehnite occur in the fractures. Polygonized quartz indicates hornfelsic recrystallization by the Hawkshaw Granite. A few tremolite grains are bent indicating renewed movement along the faults.

Felsic tuffs interlayered with the felsic flows occur as thin lenses to thick beds that extend along strike for several kilometres. Approximately 3.5 km north-northeast of Ayers Lake in map-area J-19, 20 to 30 cm thick tuff beds alternate with 1 to 3 cm thick flows. The tuff beds are graded and cross-laminated indicating tops to the northeast. The tuff is pink to greyish pink, medium-grained and displays light pink to buff weathered surfaces. It comprises 40 to 65% crystals set in a fine-grained groundmass of microcrystalline quartz, feldspar, epidote, sphene and sericite. The crystals are subhedral to euhedral feldspar (25 to 40%), quartz (15 to 30%), and biotite (1 to 5%) which range from 0.5 mm to 1.2 cm in length. The larger crystals are invariably broken, corroded, and embayed. The feldspar, which includes oligoclase and sanidine, is partially to completely altered to sericite, prehnite, and epidote. Chlorite, sphene and epidote occur as an alteration product of biotite. Flow bands, perlitic and spherulitic textures are common in the groundmass.

The crystal tuff grades laterally into volcanic breccia as can be observed approximately 4 km north-northeast of Ayers Lake and 1 km south of Otter Lake. The breccia contains fragments of felsic flows and tuff in a microcrystalline groundmass of felsic composition.

An oval-shaped body of feldspar-quartz porphyry intrudes mafic volcanic rocks approximately 700 m due north of Kilburn Lake in map-area J-20. A few exposures of feldspar-quartz porphyry occur approximately 2 km north of Ayers Lake and between Otter Brook and Upper Bear Lake in map-area I-19. The feldspar-quartz porphyry is medium to dark pink, medium-grained, and comprises 35-60% feldspar, 15-20% quartz, and 1-2% biotite phenocrysts in a microcrystalline groundmass of quartz, feldspar and chlorite. The phenocrysts are subhedral to euhedral and range in diameter from 0.2 to 3 mm. The quartz grains are commonly embayed and the feldspar phenocrysts are partially altered to carbonate, chlorite, and sericite. The biotite phenocrysts are altered to chlorite.

Quartzose Sedimentary Rocks (Unit Ds) are interbedded with mafic and felsic volcanic rocks throughout the Tobique Group in the report-area (Figure 12). Individual sedimentary beds vary in thickness from a few centimetres to several metres and some sections of sedimentary rocks have a total thickness in the order of several hundred metres. The sedimentary rocks consist of light grey, thick-bedded quartzose sandstone interbedded with medium grey siltstone and slate.

Figure 12. Thin-bedded siltstone overlain by massive felsic volcanic rocks on West Keswick River.

Outcrops on the logging road running south from Pole

Hill indicate that the quartzose sandstones overlie the fossiliferous Silurian limestone and maroon slate. A thin layer of mafic volcanics separate the Devonian from the Silurian sedimentary rocks. The mapping out of this volcanic layer outlines an anticline with Silurian rocks in its core.

Lithic Sandstone and Conglomerate (Unit Dsg) occurs in the northwestern corner of map-area I-19 where it is exposed on the Becaguimec River and an unnamed easterly flowing tributary, and on Burlock Brook. The unit consists of thick-bedded grey, coarse-grained, lithic sandstone interbedded with slate and locally with very thick beds of conglomerate containing pebbles of mafic and felsic volcanics, microgranite and lithic sandstone (Figures 13 and 14).

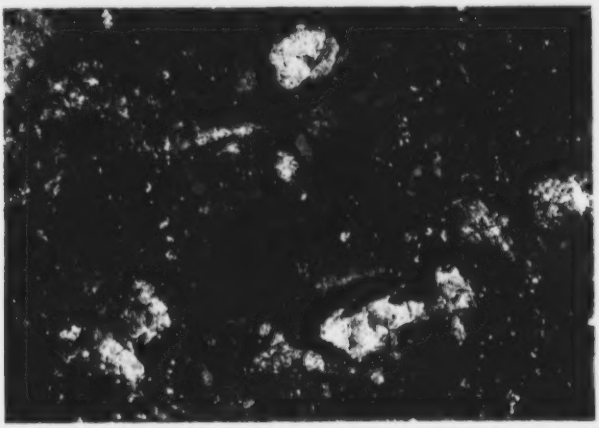

Figure 13. Felsic and mafic volcanic pebbles in conglomerate.

A fossil occurrence (GSC 98592) within lithic sandstone on the Becaguimec River contains a small spiriferid, probably a *Howellella* according to A. J. Boucot (written communication, 1981). This genus ranges in age from Late Llandovery to the Early Devonian.

Mapping in the Pole Hill area clearly shows that the lithic sandstone sequence dips and youngs off the sequence of interbedded volcanic and quartzose sandstones. The lithic sandstones are, therefore, compositionally and stratigraphically equivalent to the Wapske Formation whereas the underlying rocks belong to the Costigan Mountain Formation of the Tobique Group (St. Peter, 1978).

Figure 14. Lithic sandstone pebble in conglomerate.

DEVONIAN

Becaguimec Lake Gabbro (Unit Dml): The Becaguimec Lake Gabbro underlies the north-central part of the report area. The most common variety of gabbro is dark greyish green, medium- to coarse-grained gabbro that weathers dark green. The gabbro has a subophitic to ophitic texture and generally contains plagioclase, amphibole, clinopyroxene. Biotite and orthopyroxene occur locally. The euhedral plagioclase commonly displays normal zoning and has been partially altered to prehnite, sericite, calcite, and epidote. Hornblende is invariably altered to actinolite and chlorite. The clinopyroxene occurs in the cores of hornblende. Apatite and sphene are common accessory minerals.

Approximately 1.5 km northwest of Fish Lake in map-area J-19 an outcrop of Becaguimec Lake Gabbro displays closely spaced microfractures and bent plagioclase along twin planes indicating that the gabbro has been cataclastically deformed. In the same outcrop the gabbro is intruded by diabase dykes which are also cataclastically deformed. Subsequent to the deformation the rocks were recrystallized resulting in the growth of randomly oriented actinolite in the microfractures.

Approximately 700 to 800 m northeast of Fish Lake the Becaguimec Lake Gabbro is of troctolitic composition and comprises 70-75% plagioclase, 15-20% olivine, 5-7% orthopyroxene and minor opaques. The troctolite has a subophitic texture in which plagioclase occurs as unaltered 2 to 4 mm long subhedral to euhedral prismatic crystals. The olivine, locally altered to serpentine, is surrounded by orthopyroxene, which is rimmed by cryptocrystalline fibrous tremolite-actinolite. Orthopyroxene

also occurs as large tabular crystals partially surrounded by plagioclase laths.

A number of fine- to medium-grained diabasic dykes intrude the ophitic gabbro east of the South Becaguimec River in map-area I-19. Some of the dykes are multiple and exhibit chilling against each other (Figure 15). Narrow trap dykes locally intrude the contacts of the multiple dykes.

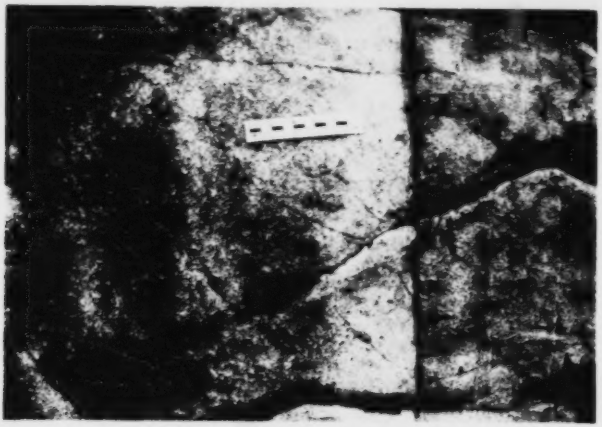

Figure 15. Medium-grained diabase dyke chilled against another diabase dyke.

Diabasic Gabbro and Monzodiorite (Unit Dm2): Two small mafic intrusions are exposed near Ayers Lake and Indian Lake in map-area I-19. Although the two intrusive bodies stand out as prominent topographic features, outcrops are scarce and occur largely in the central part of the bodies.

The gabbro at Ayers Lake, a northwesterly trending body approximately 3 km long and 2 km wide, is grey, fine to medium-grained and light grey on weathered surfaces. The gabbro contains 60-65% plagioclase, 20-25% clinopyroxene, 5% opaques and accessory apatite and sphene. Chlorite and actinolite are alteration products of clinopyroxene. Crystals of Clinopyroxene surrounded by subhedral to euhedral prismatic crystals of plagioclase form a diabasic texture. Locally the gabbro contains minor (1-5%) granophyric intergrowths of potassium feldspar and quartz interstitial to the other minerals. This and the absence of hornblende distinguishes this unit from the Becaquimec Lake Gabbro.

The gabbro at Indian Lake, a northerly trending body

approximately 3 km long and 1 km wide, is grey, fine to medium-grained and contains 45-55% plagioclase, 15-25% clinopyroxene, 10-15% chlorite, and minor actinolite, sphene, and opaques. The plagioclase is highly altered to rosettes and aggregates of chlorite and to a lesser extent, actinolite. One locality of the gabbro contains minor intergrowths of potassium feldspar and quartz and recrystallized polygonized quartz aggregate that appears to have been infilling of a vesicle.

Along the shore of Ayers Lake and due north of the lake a number of xenoliths of siltstone and limestone ranging from a few square centimetres to several tens of square centimetres are enclosed in the gabbro. The bedding trend in the sedimentary xenoliths is similar to that of the rocks in the Smyrna Mills Formation northwest and southeast of the gabbro. The gabbro at Indian Lake contains xenoliths of Lower Devonian mafic volcanic rocks against which the gabbro is chilled.

A number of stocks varying in composition from gabbro to monzodiorite are exposed in map-area I-19. The largest stock, an oval-shaped body approximately 1.75 km long and 0.3 km wide exposed on the road south of Belyea Brook in the west-central part of the map-area intrudes rocks of the Tobique Group. Two smaller irregularly-shaped bodies crop out south of the larger stock. Two small stocks, exposed along South Becaguimec River approximately 1.5 km northeast of the mouth of Little Fork Brook, intrude the Becaguimec Lake Gabbro.

Rocks of monzodiorite composition are medium to dark pinkish-grey and display light pink weathered surfaces. They contain 45-65% plagioclase, 1-15% potassium feldspar, 1-10% quartz, 0-15% clinopyroxene, 0-15% amphibole, and minor sphene and opaques. In one locality in the western part of the map-area the rocks are porphyritic with plagioclase phenocrysts up to 4-5 mm long. Plagioclase occurs as zoned subhedral to euhedral grains clouded with light red iron oxide. It is surrounded by an intergrowth of quartz and potassium feldspar forming a well-developed granophyric texture. Clinopyroxene occurs as large (1.0 to 3.0 mm in diameter) tabular crystals and tiny prismatic grains with polysynthetic twinning. The amphibole is generally common hornblende which is altered to actinolite and chlorite. Minor kaersutite has also been observed. Apatite is generally the most common accessory mineral. Variable amounts of actinolite, chlorite, prehnite, epidote, calcite and pumpellyite are present as a result of alteration of plagioclase and mafic minerals.

Felsic Intrusive Rocks: The felsic intrusive rocks in the area have been divided into four units on the basis of composition, texture, spatial relationships, and degree of deformation. Porphyritic granite (Unit Df_1) occurs as several small stocks and dykes spatially associated with the Becaguimec Lake Gabbro. The Howard Peak Granodiorite (Unit Df_2) is a foliated mafic-rich pluton. Equigranular to subporphyritic biotite granite constitutes the bulk of the Nashwaak Granite (Unit Df_3) and equigranular to megacrystic biotite granite forms the largest part of the Hawkshaw Granite (Unit Df_4).

Porphyritic Granite (Unit Df_1) occurring as stocks

and dykes in the Becaguimec Lake Gabbro is fine- to medium-grained, greyish pink, and has a texture characterized by the occurrence of larger euhedral plagioclase laths enclosing finer grained quartz and potassium feldspar. The unit varies in composition from quartz monzonite (Streckeisen 1973) containing less than 15% quartz and abundant hornblende to monzogranite containing biotite as the main mafic mineral. Dykes of this unit tend to intrude the same fractures occupied by diabase dykes.

Howard Peak Granodiorite (Unit Df_2) is a northerly trending pluton located along the eastern margin of the Nashwaak Granite in map-area J-19. The predominent rock type is dark grey, medium-grained, foliated, and varies in composition from granodiorite to tonalite. The major mineral constituents are plagioclase (40-55%), quartz (15-25%), biotite (5-20%), hornblende (0-5%), and potassium feldspar (1-10%). Sphene, epidote, allanite, apatite, zircon and opaques are accessories. The plagioclase is euhedral and exhibits oscillatory zoning. Plagioclase, hornblende and biotite have a subparallel orientation.

Near its eastern contact along the Keswick River, the granodiorite locally grades imperceptibly into ophitic gabbro. Pink granite veins commonly inject the granodiorite parallel to its foliation. Granite is particularly abundant along the western contact near Sills Lake and on Pughs Peak where it possesses a strong cataclastic foliation and fractures filled with epidote. The pervasive deformation, lack of large perthitic potassium feldspar, and local presence of hornblende serves to distinguish this granite from the massive Nashwaak Granite farther west. Devonian volcanics and sediments on the western flank of Pughs Peak are also mylonitized indicating they are separated from the Howard Peak rocks by a fault. Biotite growing over the mylonitic fabric in the deformed granite, volcanic rocks and sediments is presumably related to the post-faulting emplacement of the Nashwaak Granite.

A large xenolith of medium grey, slightly foliated hornblende-bearing granodiorite (Figure 16) found within the Hawkshaw Granite is included in Unit Df_2. Outcrops of the granodiorite can be seen on the Valley Forest Road and on the West Keswick River in map-area J-20.

Quartz-diorite dykes (qd on map-area J-19) intrude the country rocks near the eastern margin of the Howard Peak Granodiorite at the Narrows on the Nashwaak River, on the Keswick River and south of Howard Peak Lake. The dyke at the Narrows (Figure 17) is dark grey and contains small phenocrysts of plagioclase (Figure 18). Chilling is evident against the Cambrian-Ordovician quartzites (Figure 19). The plagioclase phenocrysts which exhibit oscillartory zoning are set in a fine-grained matrix of plagioclase and quartz. The original mafic minerals have been recrystallized to a metamorphic mosaic of biotite and actinolite presumably due to the contact effects of the later Nashwaak Granite.

The dyke south of Howard Peak Lake contains plagioclase, hornblende and biotite phenocrysts set in a very fine-grained matrix. The hornblende is partially replaced by biotite

and the matrix is grown over by small irregular-shaped biotite grains. This dyke resembles one observed just to the north of the area by Lutes (1981, p. 21).

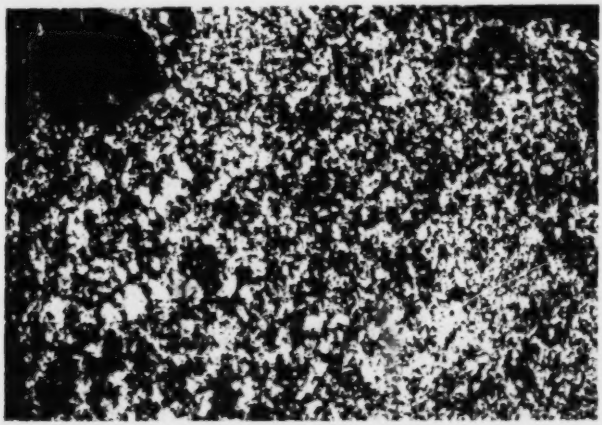

Figure 16. Hornblende-bearing granodiorite on Valley Forest Road, map-area J-20.

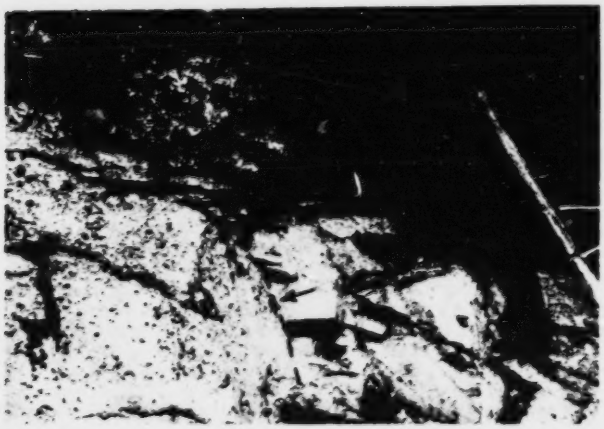

Figure 17. Contact between massive dyke to the left of hammer against thick-bedded quartzite on the right.

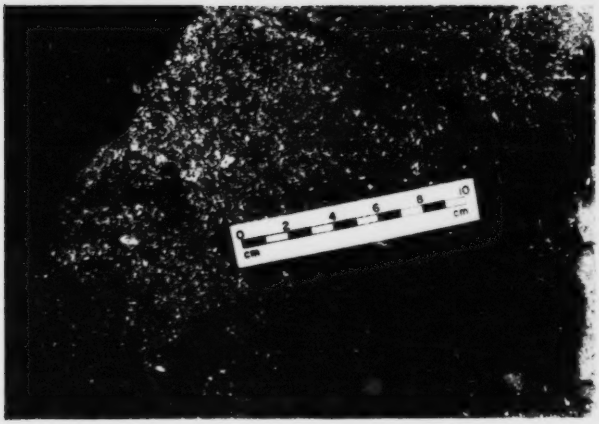

Figure 18. Porphyritic texture of quartz-diorite dyke at the Narrows.

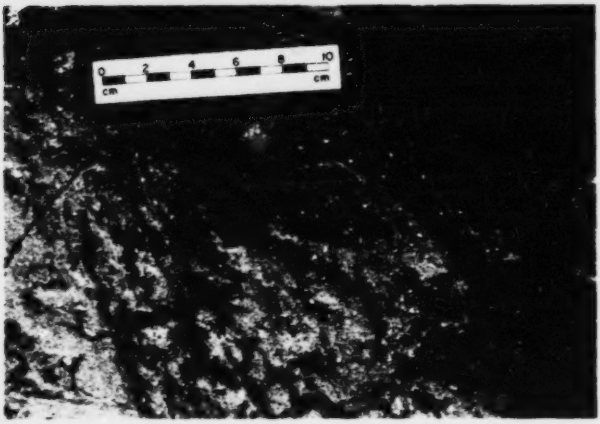

Figure 19. Chilled margin of quartz-diorite dyke at the Narrows.

The Howard Peak Granodiorite contains a number of schistose metasedimentary xenoliths derived from the Cambrian-Ordovician country rocks. The xenoliths vary from a few

centimetres to several metres in length and generally have their long dimension oriented parallel to the foliation in the granodiorite. Xenoliths are particularly abundant along the western contact of the granodiorite where they contain the assemblage: quartz, feldspar, biotite, muscovite, cordierite and andalusite together with sillimanite. A xenolith within the centre of the pluton along the Keswick River contains orthopyroxene. The andalusite porphyroblasts are randomly oriented whereas the biotite, cordierite and muscovite tend to mimic the pre-existing foliation in the rock.

The eastern contact of the Howard Peak Granodiorite with its Cambrian-Ordovician country rocks is not exposed but can be approached within a few tens of metres along the Keswick River. The contact runs north-south parallel to the foliation in the granodiorite and to the schistosity in the country rocks (Figure 20) but granite dykes locally cut sharply across the schistosity (Figure 21). Cordierite and andalusite porphyroblasts are found near the contact. Farther east at Narrows Mountain, Ordovician greywacke within 1 km of the contact is metamorphosed to biotite grade.

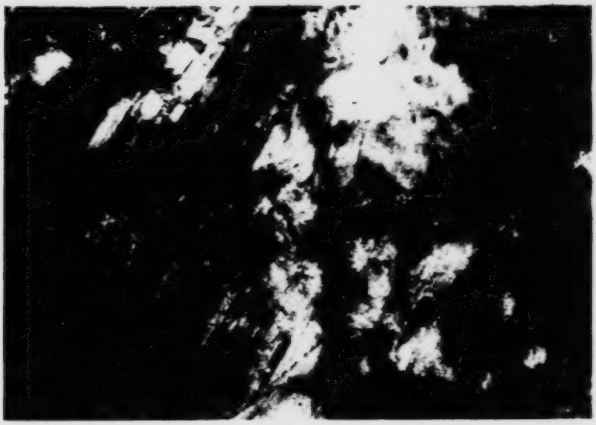

Figure 20. Schistose Cambrian-Ordovidian sedimentary rocks on the Keswick River near their contact with the Howard Peak Granodiorite.

The Howard Peak Granodiorite bears a striking resemblance to the Hartfield Tonalite (Venugopal, 1979) which has been aptly demonstrated to be a syntectonic intrusion (O'Brien, 1977). O'Brien interprets the deformation accompanying the intrusion to be pre-Acadian but Fyffe *et al.* (1981) suggests that it is Acadian.

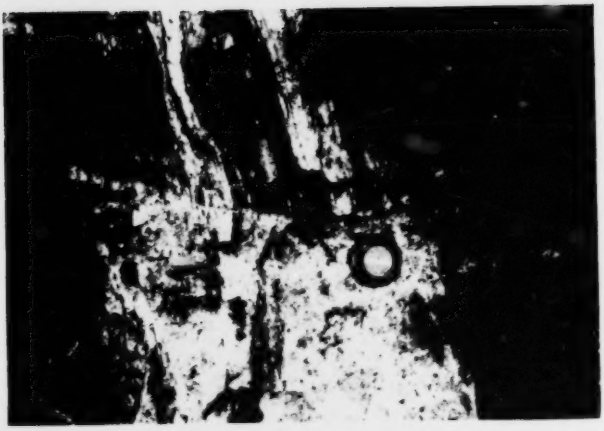

Figure 21. Subhorizontal granite dyke cutting across schistosity in Cambrian-Ordovician rocks.

The Nashwaak Granite (Unit Df_3) is exposed northwest of Sills Lake and on Spruce Peak in map-area J-19. The largest part of the pluton is a light pink, medium-grained, equigranular to subporphyritic biotite granite (Unit Df_{3a}). Quartz, perthitic potassium feldspar, and plagioclase occur in about equal amounts. Biotite forms from 10 to 15% of the rock; epidote, sphene, zircon and opaques are accessories. In the subporphyritic variety, potassium feldspar occurs as 5 to 8 mm long phenocrysts. The granite on Spruce Peak (Unit Df_{3a}) contains 2 to 5% biotite, 1 to 3% muscovite and minor euhedral garnet.

The Nashwaak Granite can be observed to intrude the Becaguimec Lake Gabbro and Howard Peak Granodiorites to the north of the report area (Lutes, 1981). The Nashwaak Granite apparently intrudes cataclastized volcanic and sedimentary rocks of the Tobique Group just to the north of Pughs Peak as these rocks are hornfelsed to biotite grade. Evidently the granite's emplacement was partly controlled by a pre-existing northerly trending fault as the contact metamorphism postdates the cataclastic deformation of the Tobique Group.

The Hawkshaw Granite (Unit Df_4), one of the main divisions of the Pokiok pluton (Lutes, 1979), can be divided into three phases: a megacrystic biotite granite, an equigranular biotite granite locally containing hornblende, and an equigranular muscovite-biotite granite.

Medium grey to pink megacrystic granite (Unit Df_{4a}) intrudes the Silurian Kingsclear Group on the southeast side of the Pokiok pluton. Exposures are found on the Keswick River

near Barton and around Crabbe Mountain in map-area J-20. The rock is characterized by an abundance of large phenocrysts of potassium feldspar (Figure 22). The contact with Silurian rocks, exposed approximately 1 km northeast of Crabbe Mountain, is sharp and cuts discordantly across the cleavage in the sedimentary rocks. Porphyroblasts of cordierite, garnet and andalusite are found up to 1 km from the contact near Crabbe Mountain and in the roof pendant at Mularchy Peak. Calcite porphyroblasts occur northwest of Hayne, 2.5 km from the southeastern contact.

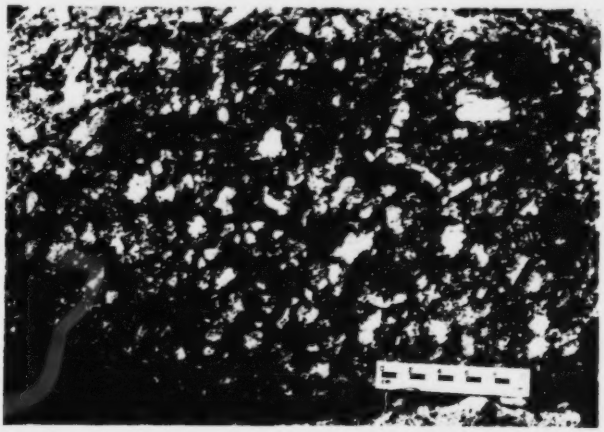

Figure 22. Megacrystic granite near Crabbe Mountain.

Equigranular granite (Unit Df_{4b}), forming the northeastern tongue of the Hawkshaw Granite, is light grey to pink, medium-grained, and contains equal amounts of quartz, potassium feldspar and plagioclase. Biotite comprises from 10 to 15% of the rock. Up to 5% hornblende is present north of Stones Brook in map-area J-19.

The granite is faulted against its country rock to the northwest. Granite near the contact on the West Keswick River is fractured and altered (Figure 23). The quartz and feldspar are highly strained, feldspar is partially replaced by muscovite and the biotite is completely replaced by muscovite and opaques. Cambro-Ordovician phyllite northwest of the granite shows no evidence of contact metamorphism and is tightly folded (Figure 4).

An area of deeply weathered, equigranular granite to the southwest of Southampton Junction in map-area J-20 has been quarried for use as road metal (Anderson, 1968, p. 35-37).

Figure 23. Fracturing in granite on West Keswick River.

Muscovite-biotite granite (Unit Df_{4c}) is exposed principally along the Keswick River in map-area J-19. It is medium to dark pink, fine-to medium-grained and equigranular. It is distinguished from Unit Df_{4b} by the presence of up to 5% muscovite. The muscovite occurs both as large blades interstitial to quartz and feldspar and as small blades replacing feldspar. The granite on the Keswick River near the northwestern contact is fractured and biotite is altered to chlorite.

MISSISSIPPIAN

In the report-area Mississippian rocks comprise a mafic volcanic unit and an overlying sedimentary unit named the Carlisle Formation (St. Peter, 1980). The Mississippian rocks are exposed in the northern half of map-area I-19 and in the northwest corner of map-area J-19.

The Mississippian Mafic Volcanic Rocks (Unit Mmv): The mafic flows are exposed along a road approximately 1 km northwest of Becaguimec Lake in map-area J-19 where they display subhorizontal to horizontal flow layering. Good exposures can also be observed approximately 250 m north of the mouth of a south-flowing tributary of South Becaguimec River. Assuming a gentle dip of 5 to 10° for the flows the overall thickness is estimated to be approximately 25-30 m.

The flows are dark grey and basaltic in composition comprising 60-70% tiny laths of plagioclase (0.05 mm to 0.1 mm long) in a 30-60% microcrystalline to cryptocrystalline ground-

mass. The plagioclase laths display a preferred orientation parallel to the flow lines. The red to brown weathered surfaces are due to the weathering of the uniformly distributed opaque minerals (iron oxide to hematite). The volcanic rocks contain large vesicles filled with quartz, calcite, and chlorite.

The nonconformity between the Mississippian volcanic flows and the underlying Becaguimec Lake Gabbro is not exposed in the area but can be approached within a few metres along the south-flowing tributary.

Similar mafic volcanic rocks occur approximately 35 km to the north-northwest where the Gladwyn Basalt unconformably overlies the Early Devonian Wapske Formation and forms the base of the Arthurette Redbeds (St. Peter, 1979).

Carlisle Formation (Unit Ms): Red conglomerate interbedded with red sandstone form the major portion of the formation. Mudstone and nodular limestone occurs locally near the top of the sequence. Although the unit is poorly exposed in the area its areal extent is outlined by red staining of soil which overlies it.

In the section along Burlock Brook conglomerate beds vary from a few centimetres to approximately 50 cm in thickness and grade upward into sandstone. The conglomerate is polymictic with pebble to cobble size subangular to subrounded fragments of felsic and mafic volcanic rocks, quartzite, vein quartz, slate, and schistose rocks. The sandstone interbedded with the conglomerate forms beds a few centimetres to 50 cm thick. The sandstone varies from very coarse to very fine and comprises 30-45% clear quartz granules, 30-35% potassium feldspar, 15-20% rock fragments, 5-10% matrix and 1-5% strained quartz. The silty matrix contains quartz, feldspar, sericite and chlorite. The rock fragments are primarily quartzite, quartz wacke, felsic porphyry, slate, and schist. Microcline perthite grains 2 to 6 mm long are the predominant feldspar.

Mudstone forms beds a few centimetres to approximately 15 cm thick, some of which can be observed along Falls Brook approximately 2 km east of Highway 104. Two beds of nodular limestone, varying in thickness from 10 cm to 20 cm, are exposed approximately 2.5 km east-northeast of Cloverdale and along a small tributary of South Becaguimec River approximately 5 km northeast of the mouth of Little Forks Brook. The limestone is greenish white and contains limestone nodules in a gritty limey matrix.

Although the actual contact was not observed, the Carlisle Formation must unconformably overlie the folded Tobique Group and the inlier of Silurian limestone. Along a south flowing stream, near the western map-border of J-19, outcrops of nearly flat-lying Mississippian mafic volcanic flows occur within approximately 300 m of the contact with the overlying redbeds and is assumed to be conformable.

PENNSYLVANIAN

Mountain View Formation (Unit Ps): The Mountain View Formation (St. Peter, 1980) underlies two flat-topped hills near the northern I-19 map-border and is sparcely exposed along a few small streams on the flanks of these hills.

The formation comprises interbedded grey conglomerate and sandstone. The conglomerate is polymictic and contains sub-angular to subrounded pebbles and cobbles of quartzite, felsic volcanic rocks, siltstone, vein quartz, feldspar and mica fragments. The matrix (5-10%) comprises a fine mixture of quartz, mica, and reddish iron oxide. The interbedded sandstone is locally cross-laminated. It comprises 65-80% quartz, 5-10% rock fragments, and 5% feldspar. The matrix, which forms 15-20% of the rock, comprises a fine-grained assemblage of quartz, mica, and amorphous iron oxide.

Although a contact was not observed in the field, the Pennsylvanian rocks are assumed to conformably overlie the Mississippian sedimentary rocks. The Pennsylvanian rocks are essentially flat-lying and the contact with the Carlisle Formation can be traced from aerial photographs.

JURASSIC

Diabasic Dyke (Unit Jm): A diabase dyke on the Keswick River north of Howard Peak Lake contains an unaltered assemblage of pigeonite, plagioclase and minor opaques characteristic of the Caraquet dyke. The location on the Keswick River is on strike with the Caraquet dyke to the northeast and with a similar dyke on the Trans-Canada Highway near Meductic to the southwest. The Caraquet dyke is late Triassic or early Jurassic in age (Venugopal, 1979).

ECONOMIC GEOLOGY

In 1959 McIntyre Porcupine Mines Ltd. drilled five packsack drill holes in the vicinity of a surface exposure of mineralization within the Becaguimec Lake Gabbro on the South Becaguimec River in map-area I-19. The holes encountered stringers of pyrite, pyrrhotite and minor chalcopyrite (N.B.D.N.R. assessment file 470268).

In 1973 Robert Connor, a local prospector, discovered galena-sphalerite mineralization in rhyolite blocks on the north-eastern end of Taffy Lake in map-area J-20. Mineralization was also discovered in outcrop in one pit. Texasgulf optioned the property and carried out soil sampling, horizontal loop, magnetic and I.P. surveys. Two subsequent 300-foot diamond-drill holes encountered scattered Pb-Zn mineralization (N.B.D.N.R. assessment file 470221).

In 1974 Texasgulf optioned property staked by local

prospector Ralph Bull approximately 2 km northeast of Taffy Lake on the West Keswick River. Seventy-five soil samples were collected and analyzed for Cu-Pb-Zn but no significant mineralization was encountered (N.B.D.N.R. assessment file 470220). In 1980 Riocanex carried out silt-soil, V.L.F.-E.M. 16 and magnetometer surveys farther to the north around Sisson Lake in map-area J-19 where a New Brunswick Department of Natural Resources geochemical soil survey indicated anomalous Pb values (N.B.D.N.R. assessment file 472646).

In 1979 Robert Connors discovered chalcopyrite-galena mineralization in chloritic felsic tuff on the Nackawic River approximately 1.6 km north of Millville. He optioned the property to Rio Tinto Canadian Exploration Limited. Rio Tinto outlined two conductive zones with a V.L.F.-E.M. survey and carried out follow-up magnetometer, horizontal loop, and geochemical surveys. A number of high copper anomalies associated with manganese concentrations were located and two diamond-drill holes were put down (N.B.D.N.R. assessment file 472612).

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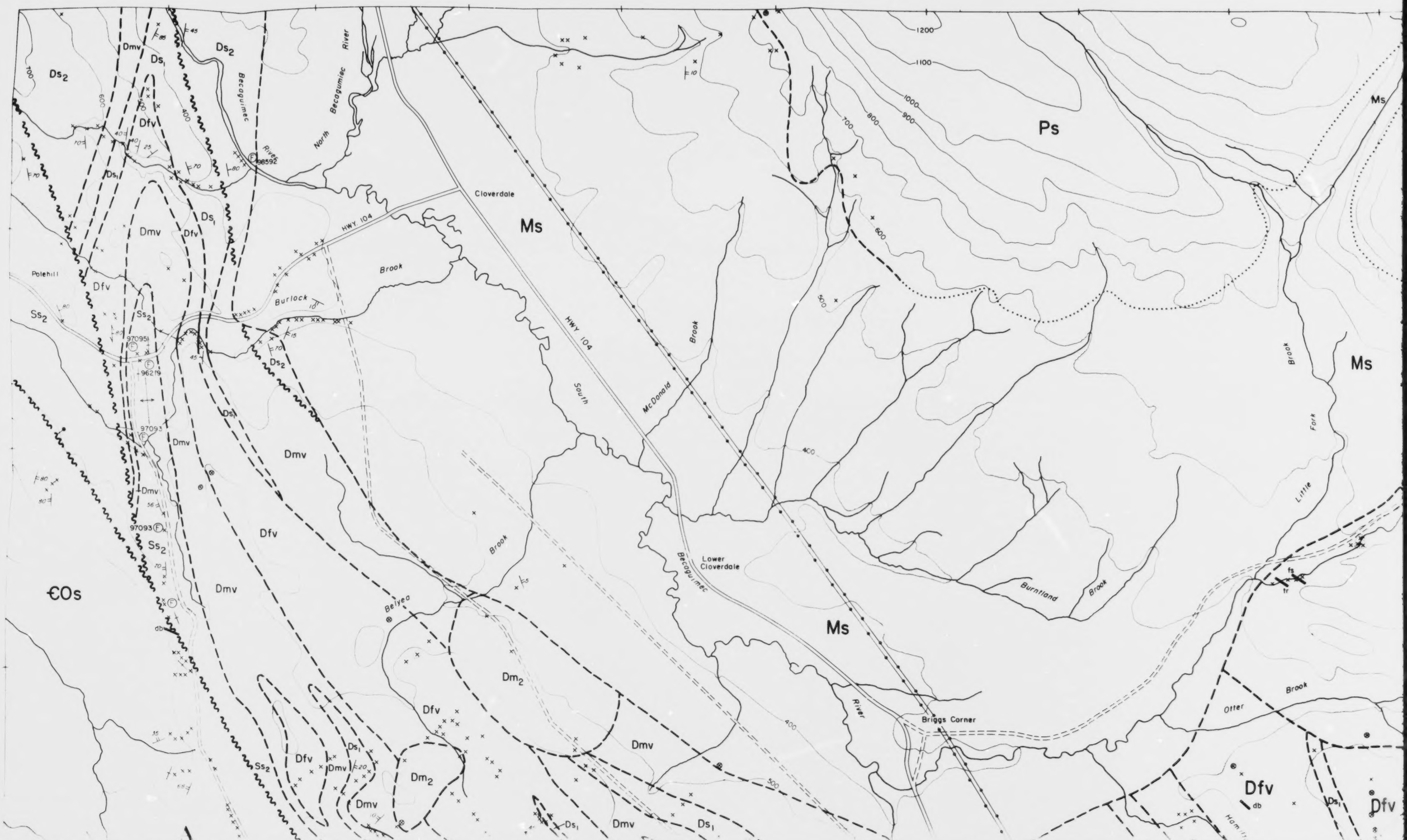
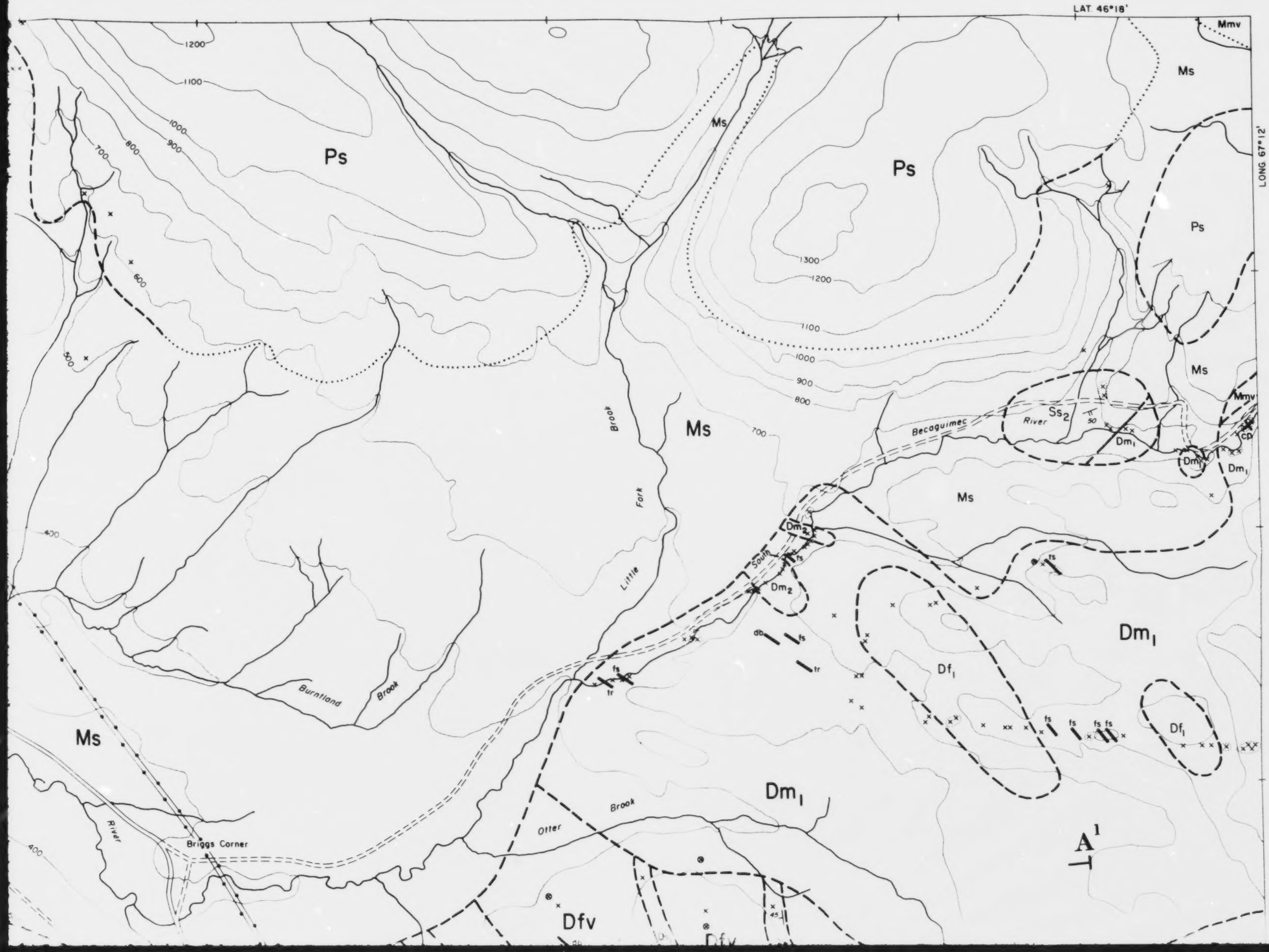
CLOVERDALE - SOUTH BRANCH BECAGUIMEC

CARLETON & YORK COUNTIES



LE - SOUTH BRANCH BECAGUIMEC
CARLETON & YORK COUNTIES

PLATE 80-73 A



PENNSYLVANIAN

Ps — *Grey sandstone and conglomerate*

MISSISSIPPIAN

Ms — *Red conglomerate and sandstone; minor red mudstone and nodular limestone*

Mmv — *Dark grey amygdaloidal basaltic flows*

DEVONIAN

Df_1 — *Greyish pink, fine-to medium-grained porphyritic hornblende-biotite and biotite granite*

Dm_2 — *Grey, fine-to medium-grained diabasic gabbro and pinkish grey monzodiorite*

Becaguimec Gabbro

Dm_1 — *Dark green to dark grey, medium-to coarse-grained, subophitic gabbro; minor gabbroic pegmatite*

LOWER DEVONIAN

TOBIQUE GROUP

Ds_2 — *Grey lithic sandstone, slate and conglomerate*

Dmv, Dfv, Ds_1 — *Dmv, medium to dark greyish green, amygdaloidal and vesicular mafic volcanic rocks*

Dfv, greyish green to pink felsic volcanic flows, tuff and breccia; minor pink quartz-feldspar porphyry

Ds_1, grey quartzose sandstone, siltstone and slate

SILURIAN

Smyrna Mills Formation

Ss_2 — *Grey calcareous slate, greyish blue limestone, maroon slate and grey laminated sandstone*

CAMBRIAN-ORDOVICIAN

ϵOs — *Light greyish green to olive green quartzite interbedded with light green slate*

Bedding, tops known (inclined)

Bedding, tops unknown (inclined, vertical)

Flow structure, tops unknown (inclined)

Slaty cleavage (inclined, vertical)

Anticline (approximate trace of axial surface)

Syncline (approximate trace of axial surface)

Rock outcrop, area of outcrop, float

Geological boundary (defined, approximate, assumed)

Fault (approximate) solid circle indicates downthrow

Dm2 Dfv Ds1 Dmv Ss2 €Os Briggs Corner Otter Brook Hamilton Brook NBEPC Indian Brook Fiddle Brook Ayers Lake Indian Lake Eight Mile Brook Nackawic River

LAT 46°12'

GOVERNMENT OF CANADA
REGIONAL ECONOMIC EXPANSION

MILES 1 0 1 2 MILES

KILOMETRES 1 0 1 2 KILOMETRES

A

1000'
0'

€Os Ss2 Dmv Ds1 Dmv Dfv Ds1 Dfv Dmv Ds1 Dmv South Becaguimec River Ms Hamilton Brook Dmv Dmv Dfv Ds1 Dfv Ds1

Anticline (approximate trace of axial surface)

Syncline (approximate trace of axial surface)

Rock outcrop, area of outcrop, float

Geological boundary (defined, approximate, assumed)

Fault (approximate) solid circle indicates downthrow side

Fossil locality with G.S.C. index number

Dyke, diabase (db), trap (tr), felsite (fs)

Line of section

cp
Mineral occurrence, chalcopyrite (cp)

Geology by D.V. Venugopal, 1979 (revised 1982)

1000 Topographic contours
Contour interval 100 feet
Elevation in feet above Mean Sea Level

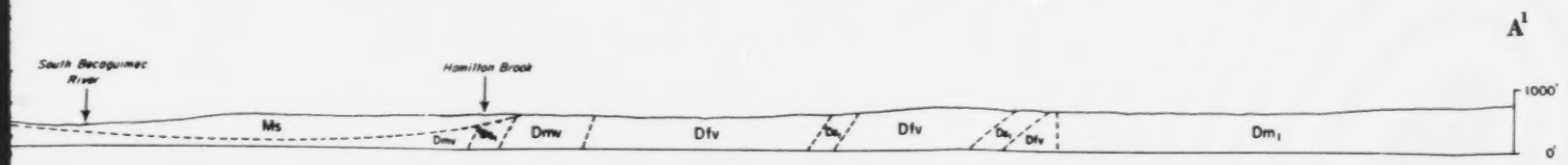
Briggs Corner
Otter
Hamilton Brook
NBEPC
Indian Brook
Fiddle Brook
Upper Bear Lake
Lower Bear Lake
Upper Northeast Lake
Indian Lake
Dfv
Dmv
Dm_2
Ds_1
db

2 MILES
0
2 KILOMETRES

NEW BRUNSWICK DEPARTMENT OF NATURAL RESOURCES

LOCATION OF MAP AREA

i-19
NTS 21 J/6
21 J/3



UPPER PARTS BECAGUIMEC, KESWICK AND NASHWAAK RIVE

YORK COUNTY

Ms
Ps
Ms
Mmv
Dm1
Df1
Dm1
Df1
Dm1
Df3a
Df3b
Df2
Df2
Dfv
COs
Ofv
COs
Ofv
Omv
Omv
Jm
Fas
Os
Os
Narrows
NARROWS MOUNTAIN
Lost Lake
South Becaguimec River
Becaguimec Lake
West
Keswick
Fish Lake
Risteen Lake
Sills Lake
Sills Brook
SPRUCE PEAK
PUGHS PEAK
HOWARD PEAK
Howard Peak Lake
1300
1200
1100
1000
900
800
700
1200
1100
1000
900
800
1000
900
800
1100
1200
1200
1100
1000

...MEC, KESWICK AND NASHWAAK RIVERS

YORK COUNTY

PLATE 80-74 A

LAT. 46°18'

LONG. 67°00'

Df2 Df4b Df4c Df3b Df1 Df2 Df2

€Os €Os €Os Os1 Os2 Os2 Os1 Os2

Ofv Ofv Ofv

Omv Omv Omv

Jm

NARROWS MOUNTAIN

HOWARD PEAK

SPRUCE PEAK

Howard Peak Lake

Sills Lake

Sills Brook

Narrows Lake

Brook

Nashwaak River

Middle Brook

River

1200 1100 1000 900 800 700 600

JURASSIC

Jm — *Diabasic dyke*

PENNSYLVANIAN

Ps — *Grey sandstone and conglomerate*

MISSISSIPPIAN

Ms — *Red conglomerate and sandstone; minor red mudstone and nodular limestone*

Mmv — *Dark grey, amygdaloidal basaltic flows*

DEVONIAN

Hawkshaw Granite

Df 4a | Df 4b | Df 4c

4a, *grey to pink, megacrystic, biotite granite*
4b, *grey to pink, equigranular biotite granite*
4c, *pink, equigranular muscovite-biotite granite*

Nashwaak Granite

Df_3 — 3a, *light pink medium-grained, equigranular to subporphyritic biotite granite*
3b, *pink equigranular biotite-muscovite-garnet granite*

Howard Peak Granodiorite

Df_2 — *Dark grey, medium to coarse-grained, foliated hornblende-biotite tonalite and granodiorite injected by granite veins and containing rafts of schist*

Df_1 — *Greyish pink, fine- to medium-grained porphyritic hornblende-biotite and biotite granite*

Becaguimec Lake Gabbro

Dm_1 — *Dark green, medium to coarse-grained, subophitic gabbro and tractolite; minor gabbroic pegmatite*

LOWER DEVONIAN

TOBIQUE GROUP

Dmv | Dfv | Ds

Dmv, *medium to dark greyish green, amygdaloidal mafic volcanic rocks*
Dfv, *greyish green to pink felsic volcanic flows and tuffs*
Ds_1, *grey quartzose sandstone, siltstone and slate*

SILURIAN

Ss_1 — *Grey to greenish grey greywacke and dark grey slate*

MIDDLE ORDOVICIAN

Belle Lake Slate

Os_2 — *Light to dark grey, fine- to coarse-grained greywacke and slate*

Pocomoonshine Volcanics

Ofv | Omv | Os

Os_1, *red and light green, manganiferous slate, grey chert, argillite and slate*
Ofv, *greyish green and pink felsic volcanic rocks, minor volcanic breccia*
Omv, *dark grey, green and purple mafic volcanic rocks*

CAMBRIAN - ORDOVICIAN

€Os — *Light greyish green to olive green quartzite interbedded with light green slate*

Bedding, tops known (inclined)

Df3b

PEAK

Howard Peak Lake

Df2

Keswick

Fish Lake

PUGHS PEAK

Dfv

Ofv

River

Trout Lake

Dm1

Ds1

Colter Lake

Sisson Lake

LAWRENCE PEAK

Df4b

Howard Valley Forest Brook

Lower Northeast Lake

Otter Lake

Dmv

LAT 46°12'

GOVERNMENT OF CANADA
REGIONAL ECONOMIC EXPANSION

MILES 1 0 1 2 MILES

KILOMETRES 1 0 1 2 KILOMETRES

A

West Branch Keswick River

Ofv

Df_{4b}

Ss_1

Df_2

Df_{4b}

Ss_1

Df_{4a}

€Os

MULARCHY PEAK

Keswick River

Howard Valley Forest Road

Brook

Stones Brook

600 700 800 900 1000 1100

500 600 700 800

0 2 MILES

0 2 KILOMETRES

NEW BRUNSWICK DEPARTMENT OF NATURAL RESOURCES

red and light green, manganiferous slate, grey chert, argillite and slate

Ofv, greyish green and pink felsic volcanic rocks, minor volcanic breccia

Omv, dark grey, green and purple matic volcanic rocks

CAMBRIAN - ORDOVICIAN

€Os Light greyish green to olive green quartzite interbedded with light green slate

Bedding, tops known (inclined)

Bedding, tops unknown (inclined)

Slaty cleavage (inclined, vertical)

Flow structure, tops unknown (inclined)

Rock outcrop, area of outcrop, float

Geological boundary (defined, approximate, assumed)

Fault (approximate)

Dyke, quartz-diorite (qd), diabase (db)

Fossil locality

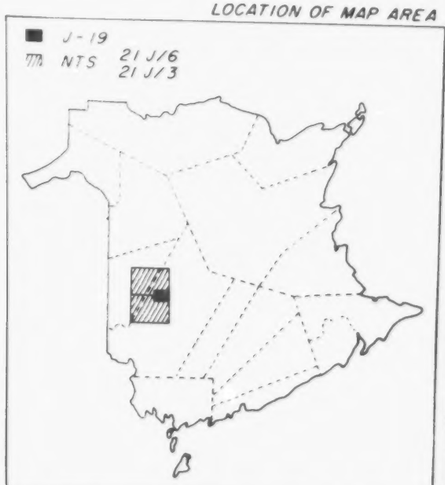
A A' Line of section

Geology by D V Venugopal, 1979 (revised 1982)

1000 Topographic contours
Contour interval 100 feet
Elevation in feet above Mean Sea Level

LOCATION OF MAP AREA

J-19
NTS 21 J/6 21 J/3



A¹

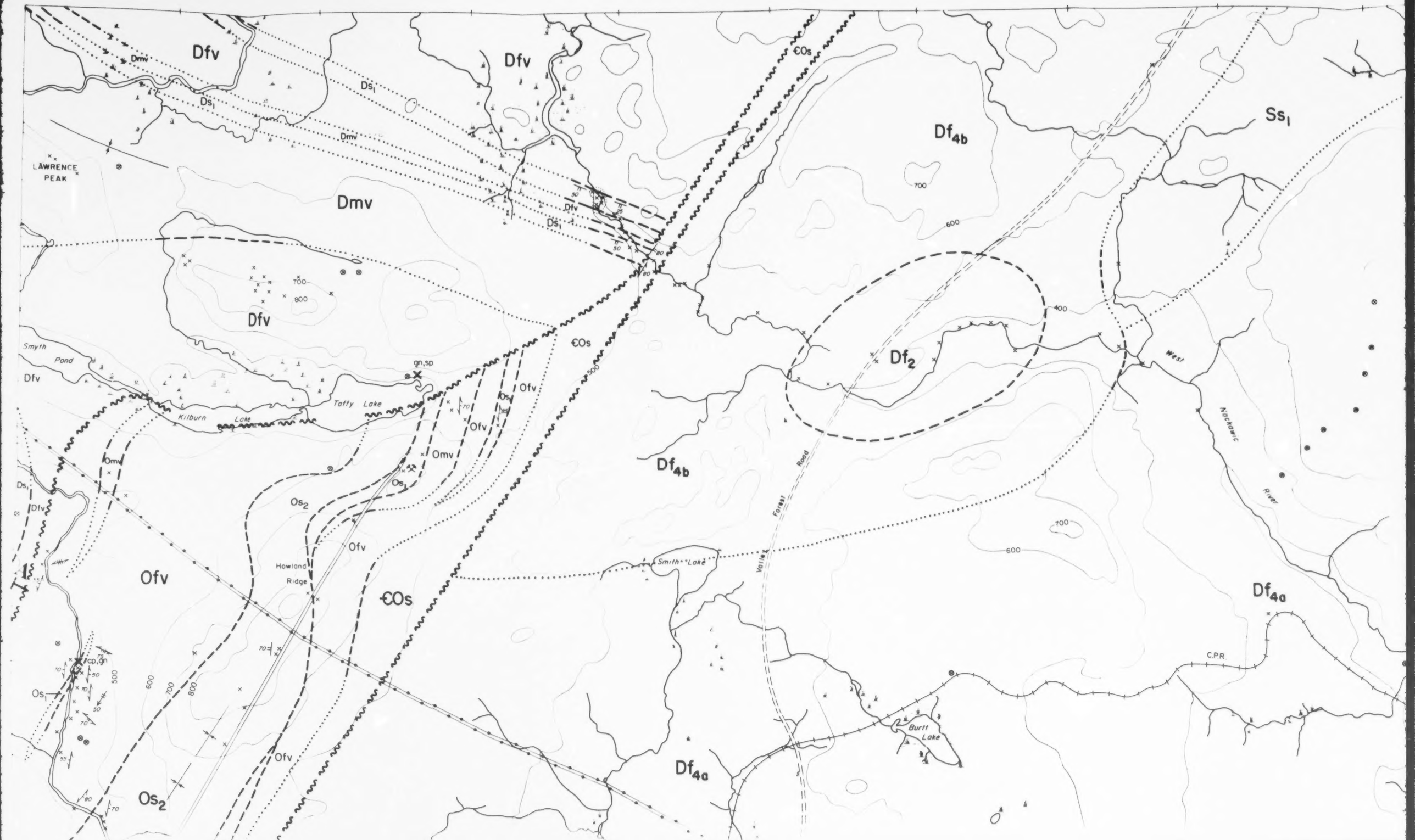
Df_{3b} Df_2 Jm €Os Omv Ofv Ofv Omv Ofv Os_2 Df_{4c}

Keswick River

Middle Brook

1000'

0'


Dfv
Dmv
Ds1
LAWRENCE PEAK
Dmv
Dfv
Ds1
Dfv
50
80
80
700
800
Dfv
Smyth
Pond
Dfv
gn,sp
Taffy Lake
Kilburn Lake
Ofv
Os1
70
Ofv
Omv
Omv
Ds1
Dfv
Os2
Ofv
Howland Ridge
Ofv
70
cp,gn
70
70
50
50
70
55
Os1
500
600
700
800
Ofv
Os2
80
70
€Os
€Os
500
Df2
Df4b
Df4b
Forest Road
Smith Lake
Valley
Df4a
Df4a
Burtt Lake
Ss1
400
700
600
700
600
Df4a
C.P.R.
West
Nagagami
River

YORK COUNTY

LAT. 46°12'

LONG. 67°00'

Df4b

Ss1

Df4a

Df2

€Os

Mularchy Brook

Johnny Brook

Middle Brook

Beaver Brook

Jones Landing Brook

West Nackawic River

Keswick River

C.P.R.

Burtt Lake

Barton

Road

700

600

500

400

300

DEVONIAN

Hawkshaw Granite

Df 4a — 4a, *grey to pink, megacrystic biotite granite*

Df 4b — 4b, *grey to pink, equigranular biotite granite*

Df2 — *Grey hornblende-biotite granodiorite*

LOWER DEVONIAN

TOBIQUE GROUP

Dmv, Dfv, Ds1 — Dmv, *medium green, amygdaloidal mafic volcanic flows and tuff*

Dfv, *light pink and grey felsic volcanic flows, tuff and breccia, minor pink quartz-feldspar porphyry*

Ds1, *grey quartzose sandstone and siltstone*

SILURIAN

Ss1 — *Grey to greenish grey greywacke and dark grey slate*

MIDDLE ORDOVICIAN

Belle Lake Slate

Os2 — *Light to dark grey, fine-grained greywacke and slate*

Pocomoonshine Volcanics

Dfv, Os1, Dmv — Os1, *red and light green, manganiferous slate, grey chert and argillite*

Dfv, *greyish green and pink felsic volcanic rocks*

Dmv, *dark grey and green mafic volcanic rocks*

CAMBRIAN-ORDOVICIAN

€Os — *Light greyish green to olive green quartzite interbedded with light green slate*

60 — *Bedding, tops known (inclined, vertical)*

Bedding, tops unknown (inclined, vertical)

S_1, slaty cleavage (inclined, vertical)

S_2, crenulation cleavage (inclined)

Axial plane of kink folds (inclined, vertical)

Axis of F_1, F_2 folds

Syncline (approximate trace of axial surface)

Metamorphic isograd (andalusite-garnet-cordierite)

Rock outcrop, area of outcrop, float

Geological boundary (defined, approximate, assumed)

Fault (approximate)

Quarry

A — A' — *Line of section*

Schematic trace of bedding

Xgn,sp — *Mineral occurrence, chalcopyrite (cp), galena (gn), sphalerite (sp)*

Os

Ofv

Os_2

Os

ϵOs

Millville

Ofv

Os

HWY 104

CPR

ϵOs

Southampton Junction

Df_{4b}

Df_{4a}

NBEPC

Df_{4a}

LONG 67°12'

LAT 46°06'

Df_{4a}

Cahill

500

400

Northeast Nackawic River

500

500

700

800

900

1000

1100

1200

Burtt Lake

CRABBE MOUNTAIN

GARNET – ANDALUSITE – CORDIERITE

Haines ville

Ss_1

Ss_1

NBEPC

A

A'

Lower Haines

GOVERNMENT OF CANADA
REGIONAL ECONOMIC EXPANSION

MILES 1 0 2 MILES

KILOMETRES 1 0 2 KILOMETRES

A

1000'

0'

Dfv

Ofv

Os_2

Ofv

ϵOs

Df_{4a}

Northeast Nackawic River

Ss_1

Fault (approximate)

Quarry

A — A' Line of section

Schematic trace of bedding

X gn,sp Mineral occurrence, chalcopyrite (cp), galena (gn), sphalerite (sp)

Geology by D.V. Venugopal, 1979 (revised 1982)

1000 Topographic contours
Contour interval 100 feet
Elevation in feet above Mean Sea Level

Burtt Lake

Barton

Kesw

CRABBE MOUNTAIN

GARNET

ANDALUSITE

CORDIERITE

Hainesville

Lower Hainesville

NBEPC

Hayne

Ss_1

A — A'

0 2 MILES
0 2 KILOMETRES

NEW BRUNSWICK DEPARTMENT OF NATURAL RESOURCES

LOCATION OF MAP AREA

J-20
NTS 21 J/3

Northeast Nashwaak River

Df_{as} Ss_1 Ss_1

A¹ 1000' 0'